

spring (not shown) able to modify its spring constant when activated may be used wherein only the stiffer constant is able to compress the substrate 16. To reduce the amplitude, and increase the wavelength by pulling at least one end cap 28, a shape memory wire 20 may be employed as previously described, and lengthened/redirected through at least one pulley (also not shown).

**[0056]** In another embodiment, the actuator 20 may consist of an active material sheet (or disk) disposed beneath the substrate 16 (FIG. 6). The planar sheet 20, for example, may be formed of SMA, so as to be caused to contract laterally or radially in all directions when activated. In this configuration, it is appreciated that activating the sheet 20 results in an approximately twenty percent reduction in surface area where maximum recoverable Martensitic strain is provided. In comparison to wire actuators, the sheet 20 applies more evenly distributed loading along the full length and width of the substrate 16. It is also appreciated that the sheet 20 in this case, and the bottom of the substrate 16 (i.e., the face opposite the overlay 18) throughout, must be allowed to float away from the overlay 18 when deformed/constrained on all lateral sides, so as to allow for the resultant increase in substrate height, for incompressible substrate constituencies. The same is true for a substrate 16 consisting of negative Poisson's ratio material.

**[0057]** In yet another embodiment, the system 10 may include a rigid member 30 embedded in the substrate 16 and drivenly coupled to the actuator 20 (FIG. 7). The preferred rigid member 30 is divided into two or more parts 30a,b that can be moved in opposite directions to produce a desired wrinkling effect. That is to say, the member 30 may be used to rectify actuation and modulate the wrinkle texture, and acts as a linkage or transmission between the actuator 20 and substrate 16. For example, an active material actuator (e.g., arcuate bi-stable actuator) 20 may be attached to a cross-bar 32 comprising a driven part 30a, and configured to push/pull the part 30a. The rigid member 30 may be inter-digitated as shown in FIG. 7; and the overlapping length, L, of the parts may be prescribed for a desired wrinkling effect. More preferably, the length, L, is adjustable, so as to tune the service life of the member 30 and adjust the amplitude and/or wavelength of the wrinkles 12.

**[0058]** In an alternative embodiment, the substrate 16 may define at least one void (not shown), such that when the embedded rigid member 30 is internally or externally actuated, and the deformation of the substrate 16 propagates to a void location, deformation is relieved at the void location causing a local deformation change in the overlay 18. If the deformation change is sufficiently close to the surfaces to be textured, then the vertical displacement caused by the actuation members is substantially amplified.

**[0059]** Another example of a transmission based system 10 is shown in FIGS. 8a,b, wherein a scissor jack fixture 34 is circumferentially employed about the substrate 16. As shown in the illustrated embodiment, the scissor jack fixture 34 is able to collapse and achieve a more linear, or expand to generate a more obtuse shape. By doing so, the fixture 34 causes the substrate 16 to undergo deformation. To drive collapse and/or expansion, an external actuator 20 and/or return mechanism 36 is drivenly coupled to the fixture 34. The actuator 20, for example, may be a shape memory wire entrained along the length of at least two of the fixture rods 34a. In the illustrated embodiment, where the wire 20 is

activated and thereby caused to achieve a shortened length, the fixture 34 is caused to expand (FIG. 8b).

**[0060]** A return mechanism in the form of a spring 36 may be coaxially aligned with at least one vertex defined by the fixture 34, such that when the fixture 34 collapses or expands, the spring 36 is caused to store energy. In the illustrated embodiment, once the actuator 20 is deactivated, the spring modulus of the spring 36 is operable to re-strain the wire 20, and return the fixture to the collapsed condition (FIG. 8a). It is appreciated that the spring 36 may also be formed of an active material (SMP, SMA, etc.), so as to be able to modify its spring constant and the behavior of the system 10 accordingly. For example, a lower spring modulus spring 36 may be used to reduce the actuation force required to expand or collapse the fixture 34, while the greater modulus could be selectively applied only when reversal is desired, and the actuator 20 has fully transformed back to its deactivated state.

**[0061]** In a preferred method of construction, the substrate 16 is mounted within the fixture 34 in the collapsed condition shown in FIG. 8b. In the squared or expanded condition (FIG. 8a) the substrate 16 is fully stretched. The overlay 18 (e.g., stiff coating) is then applied. Driving the fixture 34 into its collapsed condition relaxes the strain in the substrate 16 and consequentially causes the wrinkling phenomenon to occur. Wrinkling may be modulated proportionally with the deformation of the scissor-jack frame.

**[0062]** Another scissor-jack configuration is shown in FIG. 9, wherein a telescoping scissor jack fixture 34 is embedded within or disposed beneath the substrate 16, and used to impart longitudinal extension and lateral compression thereupon simultaneously. More preferably, a plurality of struts 38 fixedly attached at the lateral vertices (FIG. 9) may be extended to end caps 28 buttressing the sides of the substrate 16. To drive the fixture 34, a shape memory wire 20 may be drivenly coupled to the distal most vertex defined by the fixture 34. As the fixture 34 extends, the capped sides of the substrate 16 are compressed, thereby producing uni-axial wrinkles 12 in the overlay (FIG. 2). It is appreciated that depending upon the angles defined by the rods 34a, mechanical advantage with respect to force or displacement is provided.

**[0063]** This invention has been described with reference to exemplary embodiments; it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to a particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A system for selectively forming wrinkles, or modifying the amplitude, wavelength, and/or pattern of existing wrinkles upon a surface, said system comprising:

- a reconfigurable substrate presenting a first elastic modulus and Poisson's ratio;
- an overlay defining the surface, adhered to the substrate, and presenting a second elastic modulus or Poisson's ratio greater than the first; and
- at least one active material element operable to undergo a reversible change in fundamental property when